

Nd:YAG Laser Irradiation of the Human Dental Pulp: Implications as a Predictor of Pulp Hemodynamics

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Background and Objective: The aim of study this was to evaluate in vivo the pulpal blood flow rate, pulpal responsiveness, systemic blood pressure, and pulse rate during Nd:YAG laser irradiation of an isolated tooth.

Study Design/Materials and Methods: Thirteen volunteers from the Tsurumi Dental University faculty participated in this study after giving their consent to the Nd:YAG laser irradiation test protocol. Gingivo-buccal areas adjacent to mandibular canines were used for clinical evaluation. Each area was coated with India ink and treated with a Nd:YAG laser for 30 sec at 120-mJ pulses at 10 pulses/sec. Pulpal blood flow was measured by a laser Doppler flowmeter during Nd:YAG laser irradiation of the tooth. All pulp responses were measured by an electric pulp tester before and after Nd:YAG laser irradiation. In addition, the systemic blood pressure and pulse rate were monitored throughout the laser irradiation procedure.

Results: For all subjects involved in this study, the pulpal blood flow rate increased during laser irradiation. Threshold values of the electric pulp tests increased in six cases and decreased in six cases. One case showed no change. After 1 month, the threshold values for each subject had returned to previously recorded values. Neither systemic blood pressure nor pulse rate was affected during Nd:YAG laser irradiation. Pulpal blood flow was strongly influenced immediately after Nd:YAG laser irradiation, seen as an increase in the flow rate.

Conclusion: The results of this study suggest that effects of the Nd:YAG laser irradiation are similar to those of low power laser for the improvement of local blood flow. *Lasers Surg. Med.* 26:270–276, 2000.

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Key words: systemic blood pressure; laser; pulpal blood flow

INTRODUCTION

A number of studies [1–11] have reported on the potential usefulness of pulsed Nd:YAG laser irradiation for different types of dental treatment including alteration of lipopolysaccharide components of various bacteria, treatment of perforation lesions during root canal preparation, the induction of pulpal analgesia, treatment of acute and

chronic dentin hypersensitivity, and removal of carious dentin. Sato et al. [12] reported that using

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Accepted 10 August 1999



Fig. 1. Nd:YAG laser irradiation and pulpal blood flow measurement. The gingival area was coated with India ink.

a laser Doppler flow meter resulted in an increase in the local blood flow of the maxillary oral mucosa by the stellate ganglion block. By employing these research data, low-level reactive laser irradiation energy has been applied to many human patients who presented with various chronic pain syndromes [13]. Use of low-level laser irradiation has also been suggested as an appropriate technology for improving the blood flow rate and for creating an antiphlogistic effect. Previous data from the Tsurumi Dental research group focused specifically on the effects and the biological principle of high-power Nd:YAG and Er:YAG laser irradiation [1,2,14,15]. In addition, we examined the use of Nd:YAG laser irradiation for its anesthetic effect on the gingival surface [3]. However, the possible mechanisms regarding its anesthetic effect are still unclear.

The aim of the present study was to evaluate *in vivo* pulpal blood flow, pulpal responsiveness, systemic blood pressure, and pulse rate by Nd:YAG laser irradiation and to gauge its capability as an anesthetic to the pulp.

We recently measured pulpal blood flow by using a laser Doppler flow meter. From these data, we hypothesized that this Nd:YAG laser irradiation technology could be applied to the diagnosis of pulp diseases in an attempt to gain increased differential data for making a proper clinical diagnosis.

MATERIALS AND METHODS

Before any experimental Nd:YAG laser irradiation protocol was initiated, the proposal was evaluated and approved by the Tsurumi University Review Committee. All subjects were fully informed of any potential complications which were perceived as being associated with the use of Nd:YAG laser irradiation on human subjects, as outlined in this study. The 13 adult volunteers who participated in this study (five men, eight women) had a mean age of 24.6 years. The experimental site for each patient was an area of keratinized and nonkeratinized gingiva, 2 mm below the mucogingival line, adjacent to the mandibular canines [7]. All teeth adjacent to the test areas were normal, without any restoration or pathology such as caries. In addition, all of the adjacent periodontal and alveolar tissues were normal with clinical and radiographic evaluation. The gingival areas were coated with India ink and immediately irradiated with a Nd:YAG laser (American Dental Technology Pulse Master, Christi, TX) at an energy density of 50 J/cm² (30 sec at an energy level of 120 mJ pulses at 10 pulses/sec; Fig. 1).

In Vivo Measurement of Pulpal Blood Flow

A customized self-cured acrylic stent was fabricated for each patient's tooth; the stent ex-

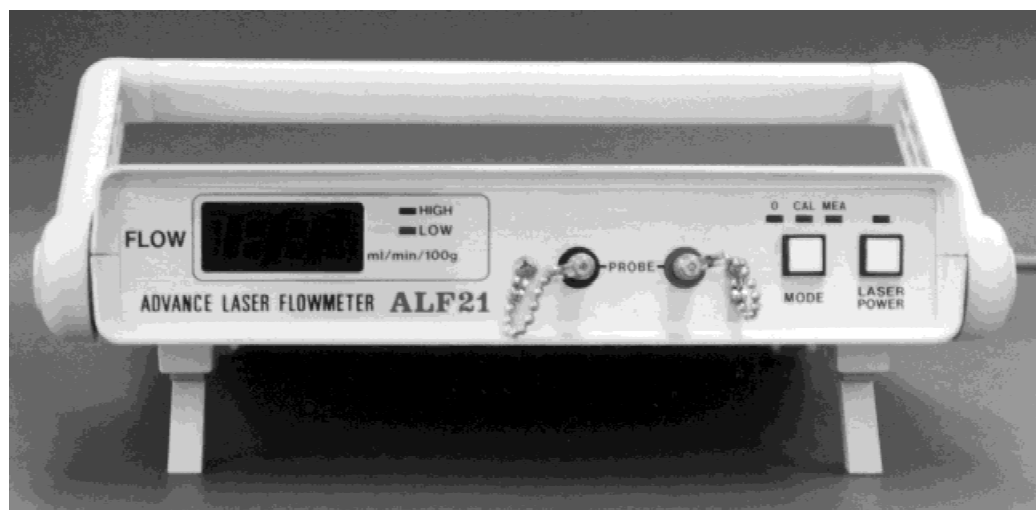


Fig. 2. The laser Doppler flow meter was used before, during, and after each Nd:YAG laser irradiation treatment.

tended to one-third of the height of the buccal crown. A 3-mm-diameter hole was bored from the buccal surface of the stent to allow access for insertion of the flow meter probe. The pulpal blood flow was measured with a laser Doppler flow meter (ALF21 Advance, Tokyo, Japan) before, during, and after each Nd:YAG laser irradiation procedure (Fig. 2).

Pulpal Vitality/Sensitivity

Pulp vitality/sensitivity was measured with an electric pulp tester (Vitality Scanner, Analytic Technology, Redmond, WA). Tests for tooth pulp vitality/sensitivity were measured for each tooth before each Nd:YAG laser irradiation procedure and 1 month after laser irradiation (Table 1). The vitality/sensitivity of each tooth was measured on a scale of 1–80 units by using the gauge on the Analytic Pulp Tester according to the manufacturer's instructions.

Systemic Blood Pressure and Pulse Rate

The systemic blood pressure for each patient's pulse rate was monitored with a BP-8800SF (COLIN, Aichi, Japan) during the entire Nd:YAG laser irradiation procedure. Each subject was allowed to relax alone in a quiet room for at least 10 min before any Nd:YAG laser irradiation procedure or examination. This rest time was used to stabilize systemic blood pressure and pulse rate for each volunteer.

Statistical Data

Data were statistically evaluated with a paired t-test. A value of $P < 0.005$ was considered statistically significant.

TABLE 1. Mean \pm SD Threshold Values for the Electric Pulp Tests Before and 1 Month After Laser Irradiation

Unit	Before	1 Month after
Threshold value	31.3 \pm 9.9*	32.4 \pm 15.2*

*Not significant. N = 13 subjects.

RESULTS

Pulpal Blood Flow Measurement

In all 13 subjects, the pulpal blood flow rate values increased during laser irradiation. An increase in the mean pulpal blood flow rate was recorded at each 5-sec interval during Nd:YAG laser irradiation of the tooth (Fig. 3). In comparing pulpal blood flow rate before and during laser exposure, there was a significant increase ($P < 0.005$) in pulpal blood flow rate during laser irradiation. Figure 4 shows the increase in pulpal blood flow rate for each subject. Depending on the subject, the pulpal blood flow rate increased by 9–23 times over the resting rate.

Pulpal Responsiveness

The threshold value of the electric pulp test increased in six subjects (Fig. 5). A decrease in threshold value was noted in six subjects, and there was no change in threshold value for one subjects. The threshold values of the electric pulp test returned to approximately baseline levels for all subjects 1 month after Nd:YAG laser irradiation.

Flow rate (ml/min/100g)

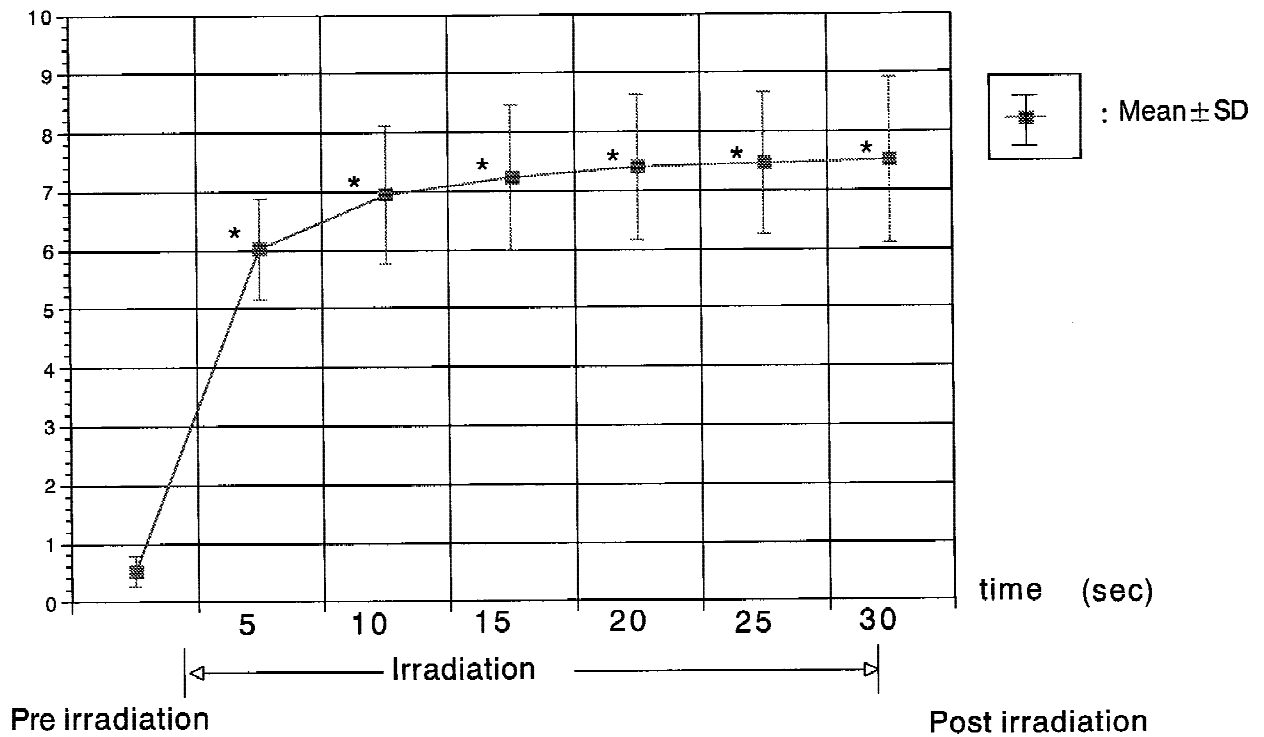


Fig. 3. Mean pulpal blood flow rates before and during laser irradiation treatment.

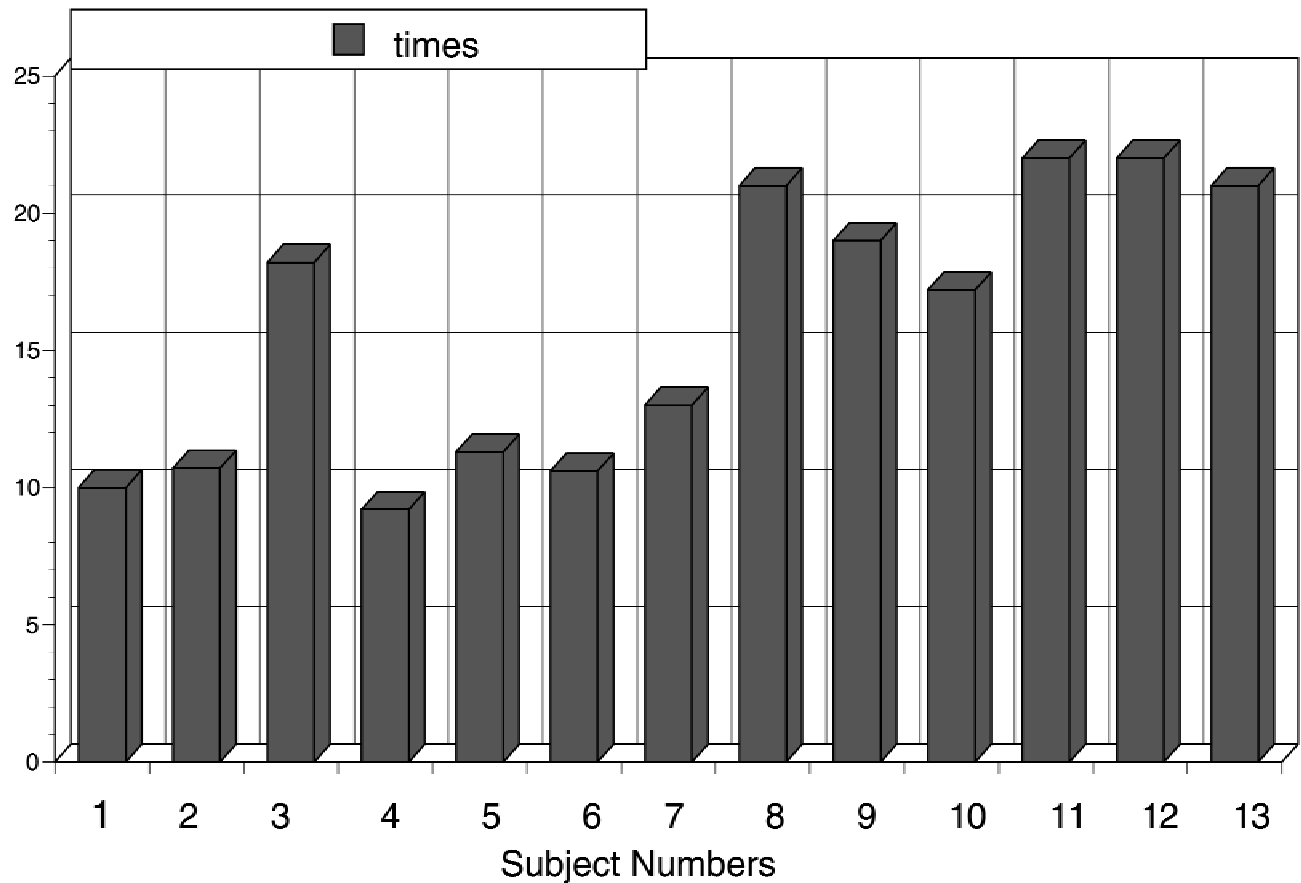


Fig. 4. Increase in pulpal blood flow rate for each subject after irradiation treatment.

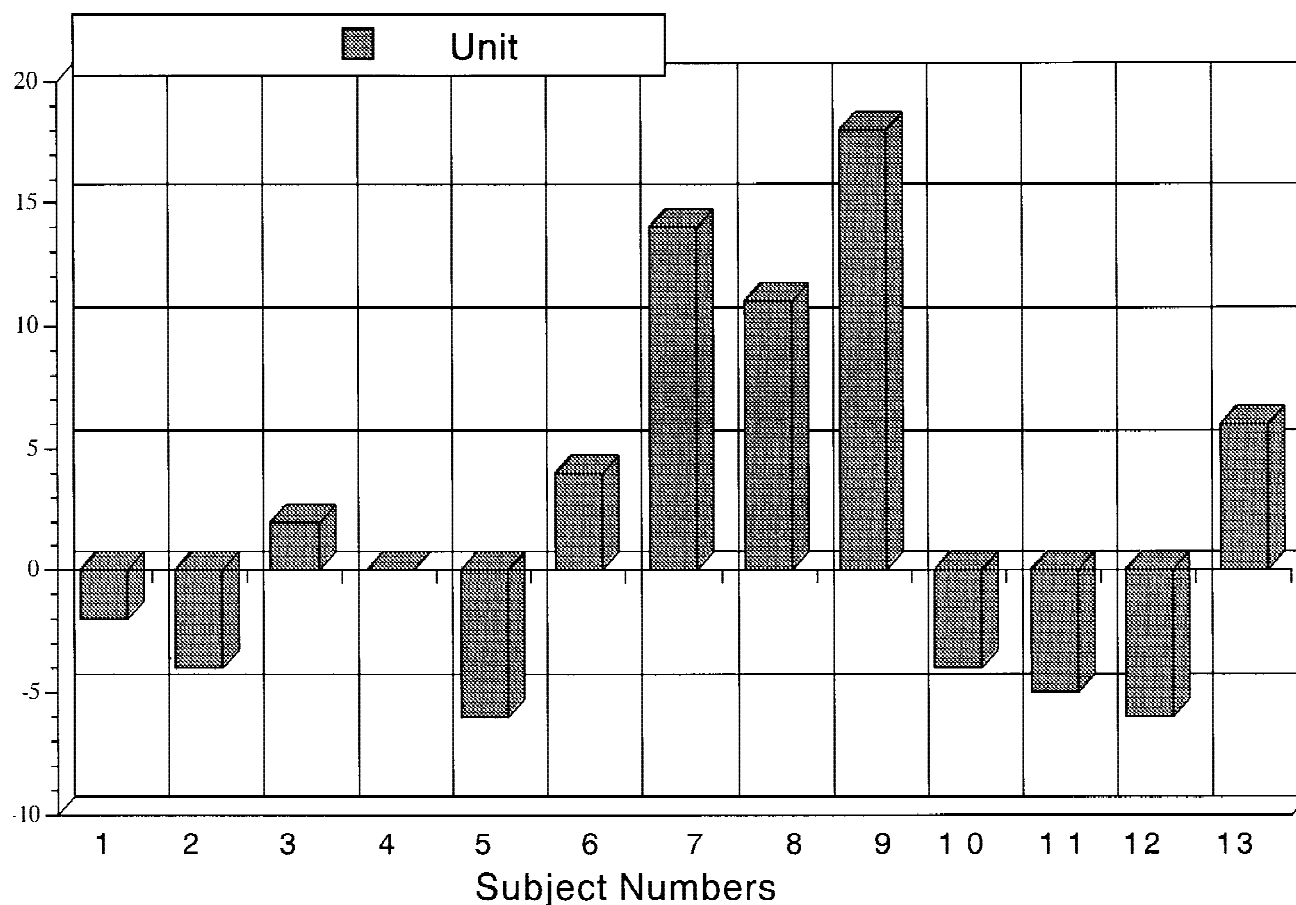


Fig. 5. Threshold values of the electric pulp tests for each subject immediately after irradiation treatment.

Systemic Blood Pressure and Pulse Rate

No significant changes in systemic blood pressure and pulse rate were found during laser irradiation of the tooth (Fig. 6).

DISCUSSION

Laser Doppler flowmetry (LDF) is a noninvasive and simple method in which to measure blood flow. In addition, LDF has been applied as a means to diagnose the vitality of dental pulps.

Laser application adjunctive procedures have been described in several studies [7–11]. In a previous study [3], we tested the anesthetic effect of Nd:YAG laser irradiation on the gingival surface and evaluated pulpal blood flow rate and pulpal responsiveness during Nd:YAG laser irradiation.

During that study, neither the systemic blood pressure nor the pulse rate was affected during Nd:YAG laser irradiation. However, pulpal blood flow was strongly influenced immediately after Nd:YAG laser irradiation, showing an increased rate of flow as measured by LDF. The results of that study suggest that a low-energy dose of Nd:YAG laser irradiation therapy could improve the dental pulpal blood flow. Whittters et al. [5] reported that laser treatment produced a small change in the pulpal sensitivity of the tested teeth.

Parkins and Miller [4] reported that a 4-min treatment with 50-mJ Nd:YAG laser irradiation pulses at 15 pulses/sec applied to the coronal surfaces of premolar teeth did not significantly alter the electric pulp testing vitality/sensitivity thresholds.

The data from that study agree with the findings of Goodis et al. [6], who measured pulp responses by electric pulp testing 1 month after

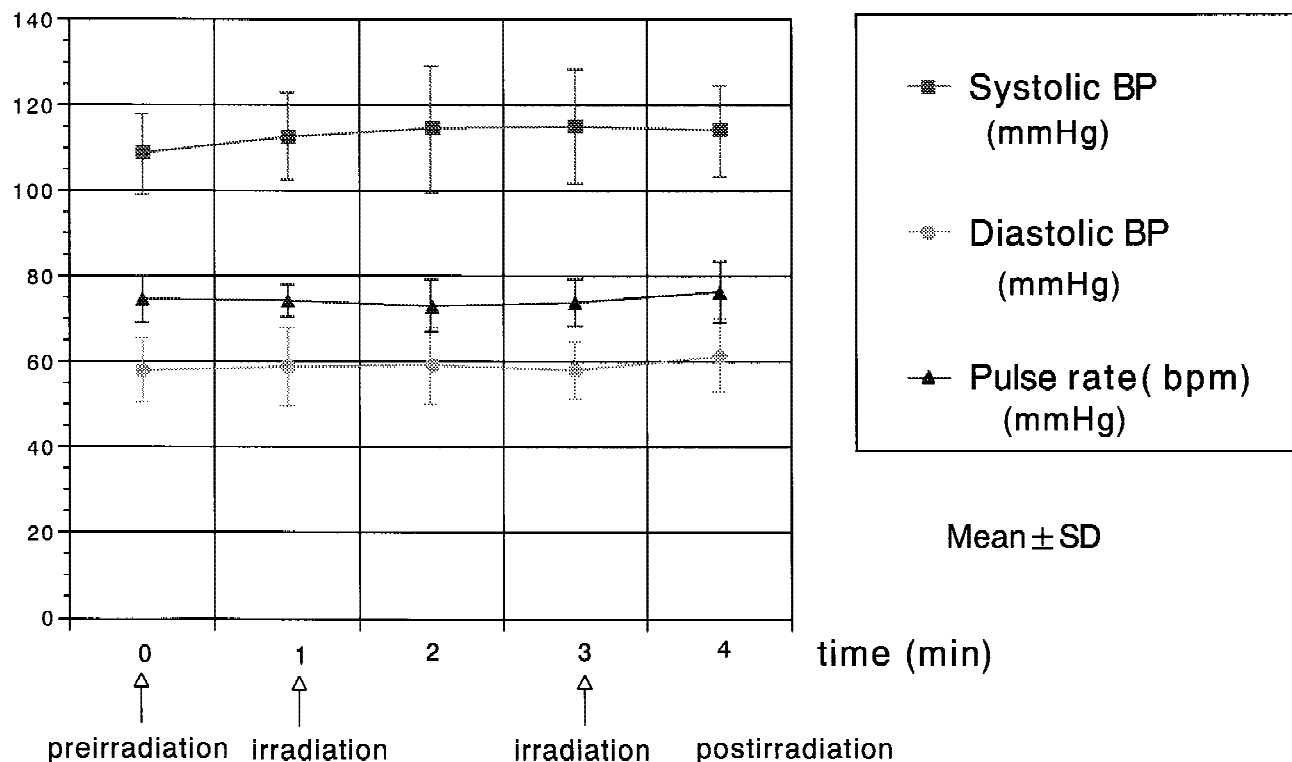


Fig. 6. Blood pressure and pulse rate during irradiation treatment.

Nd:YAG laser irradiation. They reported that the pulp response of all of the treated teeth had returned to baseline values at 1 month after laser irradiation.

One reason for the different data reported by these studies may be the effects of the different measurement values of Nd:YAG laser irradiation conditions and methods between studies.

Our research group will continue our Nd:YAG laser irradiation studies by looking at the variable conditions in detail. At the same time, we will continue to examine the mechanism of increasing pulpal blood flow rate with Nd:YAG laser irradiation in those teeth that have been diagnosed with various types of pulp pathology.

CONCLUSIONS

Pulpal blood flow was strongly influenced immediately after Nd:YAG laser irradiation, and the pulpal blood flow rate increased.

Systemic blood pressure and pulse rate were not affected during Nd:YAG laser irradiation of an isolated tooth.

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